VI.—*On recent Tornadoes in Bengal with special reference to the Tornado at Dacca on April 7th*, 1888. *In two Parts.* Part I. *A Description of the Meteorological Conditions in Bengal which accompanied the Formation of the Dacca Tornado.—By* Alex. Pedler, *Offg. Meteorological Reporter to the Government of Bengal.* Part II. *A full Description of the actual Phenomena of the Dacca Tornado.—By* A. Crombie, M. D., *Civil Surgeon of Dacca.*

(With Plates XXIV.—XXIX.)

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Part I.

Meteorological Conditions accompanying the Dacca Tornado.

By Alex. Pedler.

Amongst the very varied meteorological phenomena which are commonly met with in India or in Bengal, tornadoes are fortunately of rare occurrence. So rare are they in most countries that few people, except those living in the United States, ever have an opportunity of witnessing one. On account of their rarity in India and of the rather loose manner in which such names as cyclones, whirlwinds, dust-storms, and nor'-westers are sometimes applied to classes of storms which have no right to them, it may be well to state that whirlwinds, waterspouts, tornadoes, dust-storms, and even nor'-westers, are all closely connected phenomena, differing from each other in such particulars as dimensions and intensity, or the degree in which the moisture present is condensed and becomes visible, though more or less closely connected in the causes which give them birth. Such storms as these are, however, widely different from true cyclones both in the manner of their formation and in their phenomena. Thus, the largest tornadoes are vastly smaller than the smallest cyclones, so that there is no difficulty in distinguishing between the two classes. The cyclones with which we are familiar in India, and particularly in the Bay of Bengal, are formed over sea areas when the conditions of pressure are very uniform, when the air motion is small over the area where the storm forms, and when the air is of high temperature and nearly saturated with moisture. The formation of a cyclone is apparently only possible when the energy of the storm can be supplied by the rapid inrush of moisture-laden winds in large volumes, and the actual formation of it appears to follow on or to be connected with excessively heavy and torrential rain over a small area. Again, cyclones take time to generate, and they are frequently in existence for days before they attain their maximum strength, and the diameter of the area of hurricane winds is rarely less than 100 miles. Cyclones are also as a rule slow moving storms in

India, averaging perhaps 8 to 10 miles an hour, and they rarely travel faster than about 15 miles an hour, so that consequently a place visited by a cyclone remains under its influence usually for some hours; and, finally, the whole track of a cyclone may be many hundreds of miles in length. Tornadoes or whirlwinds, which, perhaps, from their destructive energy, are alone likely to be confounded with cyclones, are of very different nature. It is true, cyclones and tornadoes are both circular storms, and, in the Northern hemisphere, the rotation of the winds round the centre of these storms is against the hands of a watch; and in this point they agree, but they differ in many others. As the result of the examination of the character of 600 tornadoes in the United States,* their average size is found to be about 360 yards, the velocity of their progression about 30 miles an hour, the average time consumed by the tornado cloud in passing a given point about six minutes, and the average length of the storm track about 28 miles. Another point in which tornadoes differ completely from cyclones is that tornadoes have a distinct diurnal periodicity, usually occurring from 4 to 6 P. M., and they may occur at any season of the year, while fierce cyclones in the Bay of Bengal are confined to limited periods of the year, and they can have, from the nature of the case, no diurnal periodicity at all. It might, however, be objected that perhaps a tornado might grow to a cyclone, but up to the present time such an action has never been known to occur, and thus it must be admitted that there is a sharp line of demarcation between the two classes of storms.

A tornado, briefly described, is merely a whirlwind of excessive violence, and the tornado cloud usually takes the shape of a funnel, though such descriptions as "cone-shaped," "inverted funnel-shaped," "hour-glass-shaped," &c., sometimes occur. The tornado cloud has generally four movements (1) a motion of translation which is in most cases from the south-west to the north-east at perhaps an average rate of 28 miles an hour, (2) a violent rotating motion, the winds moving against the hands of a watch, (3) a swinging to and fro, so that the path of the storm frequently becomes very irregular, and sometimes (4) a rising and falling motion. With reference to the last movement, tornadoes have been seen by observers to travel actually for some distance through the air with the lower point of the tornado cloud at a considerable distance from the ground and simply to strike the ground from point to point.

The destructive effects of the tornado seem to be vastly more violent than those of cyclones, and the area of destruction is most sharp-

* Finley, Professional Papers of U. S. Signal Service, Series No. VII., Washington.

ly defined. The effects of tornadoes are in fact almost incredible, and they are due to both lateral and ascensional force. Masonry buildings are almost ground to powder by the lateral force; and, with reference to the uplifting power of tornadoes, it is on record that on June 4th, 1877,* a tornado passed over Mount Carmel (Illinois) and swept off the spire vane and gilded ball of a church and carried them bodily 15 miles in a north-easterly direction.

Previous Tornadoes in Bengal.—Tornadoes seem to have been rather more frequent in Bengal than appears to be commonly supposed, though, when compared with other regions, such as the United States, their occurrence may be considered very exceptional. In the United States, however, sometimes 10 or 12 tornadoes are known to occur in different districts in a single day, and in the year 1884 no less than 180 tornadoes were recorded by the Meteorological Department in different parts of that country. In Bengal, previous to the year 1870, there appear to be only two or three well authenticated cases of tornadoes on record.† One occurred on the 8th April in the year 1838 in the District of the 24-Pergunnas, and it passed close to Calcutta and was attended with great damage. This storm, which is described by Messrs. Floyd and Patton,‡ was a very violent one and destroyed several villages. Its track is rather difficult to trace, but it appears to have passed near Dum-Dum, through Baliaghata a short distance to the east of Calcutta, and through Sonarpur S. E. of Calcutta on the South-Eastern State Railway. Its course was said to be southerly, a very unusual circumstance. Its track was roughly 16 miles long by $\frac{1}{4}$ to $\frac{1}{2}$ a mile broad, and it lasted for 4 hours. The number of persons killed was 215, and the wounded, which were numerous, were sent to the Alipur Hospital. An observer at Dum-Dum says, one of the hail-stones which fell at that place during this storm weighed three and a half pounds. In passing, it may be mentioned that appended to the description of this storm there is a statement of a mass of ice, apparently a conglomeration of hailstones, and measuring 19 feet 10 inches, having fallen in the year 1838 at Nowloor near Dharwar.

Another tornado occurred at Pundooah (Hooghly District) on May 1st, 1865, and is described by Babu Chandra Sekar Chatterjee in the Proceedings of the Asiatic Society of Bengal.§ The diameter of its vortex appears to have been about 200 feet, and its rate of advance in a north-easterly direction about 10 miles an hour. It occurred at

* Buchan and Balfour Stewart's article on Meteorology in Encycl. Bri. 19th. Ed.

† Some of these storms are described in Blanford's Indian Meteorologist's Vade Mecum.

‡ J. A. S. B., 1838, p. 422.

§ P. A. S. B., for 1865, p. 124.

6 to 6.30 P. M., and, according to the statements made, its track must have been at least 3 to 4 miles long. It killed 20 persons and did a large amount of damage. The rotation of the winds in the storm was against the hands of a clock.

Major Sherwill* in 1860 describes several waterspouts (phenomena of similar nature to tornadoes) which he had observed in and near Calcutta previous to this date; and one which occurred on October 7th, 1859, is described by him as having been 1500 feet in height and having inundated half a square mile of country to a depth of six inches.

These, however, are the only clear cases of such storms I can find in Bengal previous to 1860. After this date either these storms have become much more numerous, or, as is more probably the case, owing to the more accurate records kept of such phenomena, our knowledge of their occurrence has become more complete. Thus, Mr. W. G. Willson,† formerly Meteorological Reporter to the Government of Bengal, states there were whirlwinds in April 1871 and September 1872 in the Nadia District, also a rather severe one at Satkhira‡ (24-Pergunnas District) on 25th April, 1872, one at Bhadalia§ (Nadia District) on February 11th, 1874, and another at the same place at 5 P. M. on 16th September 1874.

In the case of the Satkhira storm of April 1872, Mr. Willson considered that it accompanied, or was in some way connected with, the passage of a low pressure area through Bengal at the same time, and he states that the storm moved in the same direction as the trough of low pressure. This storm, however, was very small and only caused three deaths.

The most violent storm of this kind in Bengal on record is described by Mr. Fasson.|| It occurred in the Mymensingh District on March 26th, 1875, and it partially destroyed the villages of Uladah and Chamburi. It seems to have originated over the bed of a large river, instead of, as is usually the case, over hot plains. In this instance, the duration of the whirlwind was 20 minutes, the width of its path 250 yards, and the length of its course from formation to dissipation a little over two miles. Its course was almost exactly from south-west to north-east, and it occurred just after dusk. The whirlwind seems to have been accompanied with a fiery appearance or ruddy glare, and, though it was a storm of great violence, it did comparatively little damage to life and property, as the greater part of its path was over the open country.

The Dacca tornado now described by Dr. Crombie appears to have been very similar in character to that which visited the Mymensingh

* J. A. S. B. Vol. XXIX, p. 366.
† P. A. S. B. 1875, p. 107.
‡ P. A. S. B. 1872, p. 96.
§ P. A. S. B. 1875, p. 107.
|| P. A. S. B. 1875, p. 104.

District in 1875, as to size, duration, and general direction, but, as its track lay through a populous town instead of the open country, the amount of damage done by it was very large.

METEOROLOGICAL CONDITIONS USUALLY PRECEDING TORNADOES.—As will be seen from the preceding description, the number of tornadoes which have occurred in Bengal (and probably in India also), and of which accurate records are obtainable, has been far too small to enable any scientific work to be undertaken as to their causation. In the United States, however, as previously mentioned, tornadoes are frequent, and, under the direction of the War Department, the Signal Service of that country has done most valuable work on these storms. For a full description of the effects of these storms and of the meteorological conditions which precede them, the works of Lieutenant John P. Finley may be consulted.* But even though Mr. Finley has worked out the records of about 800 tornadoes, he has been unable to lay down more than very general statements as to the meteorological conditions which precede such storms, and, in his last work published in 1885, he states, "The following are some of the conclusions which appear to proceed from a study of the relation of tornado-centres to areas of barometric minimum.

1. That there is a definite portion of an area of low pressure within which the conditions for the development of tornadoes are most favourable, and this is called the dangerous octant.

2. That there is a definite relation between the position of tornado regions and the region of high contrasts in temperature, the former lying to the south and east.

3. That there is a similar definite relation of position of tornado regions and the region of high contrasts in the dew point, the former being, as before, to the south and east.

4. That the position of tornado regions is to the south and east of the region of high contrasts of cool northerly and warm southerly winds, a condition that appears to be dependent upon the preceding, and is of use when observations of temperature and dew point are not accessible.

5. The relation of tornado regions to the movement of upper and lower clouds presents some interesting points for study, but, as yet, no decided results.

6. The study of the relation of tornado regions to the form of barometric depressions appears to show, that tornadoes are more frequent when the major axes of the barometric troughs trend north and south or north-east and south-west, than when they trend east and west."

* In such papers as Professional Papers of the Signal Service War Department. No. IV. Tornadoes of May 29th and 30th, 1879. No. VI. Report on the character of 600 tornadoes. No. XVI. Tornado Studies for 1884.

In reference to the connection which Mr. Finley appears to find between the passage of barometric minima and the possibility of formation of tornadoes, it will be remarked that Mr. Willson apparently traced a connection between the two same facts in the case of the Satkhira tornado of 1872.

According to the meteorological charts which accompany Mr. Finley's Memoirs, it would appear that the position of the formation of tornadoes is to the south and east of the line taken during the advance of the barometric minimum, and that it occupies the same relative position to the high contrasts of temperature and humidity. Further, it is probable that the track of the tornado bears a definite relation to the position of these same violent contrasts. In all these cases, however, it is not to be assumed that the tornado will be formed in close proximity to barometric minima or to contrasts of temperature and humidity, for the researches in America show that these actions may only exist long distances, perhaps 200 or 300 miles, away. Beyond these rather vague statements, it does not appear safe to go, but it is clear there must be some further cause or causes at work which determine the actual formation of the storm, but of which at the present time we have no knowledge.

Similar actions or contrasts of temperature and humidity brought about by more or less opposing wind systems blowing in neighbouring districts are common in Bengal during the hot weather season. It frequently happens that hot, dry, north-westerly winds may be blowing a short distance inland, while moist, comparatively cool, southerly or south-easterly winds are blowing to the south of them, or along the coast and in the neighbouring districts. Such actions usually, it is believed, produce the nor'westers with which all are familiar, and which are of very frequent occurrence in Bengal from about February to June. The history of some of these storms has been worked out by Mr. Eliot.* Experience has shown that nor'-westers do not occur either when a steady, hot, and dry westerly or north-westerly current is blowing over Bengal, or even when a steady easterly or south-easterly current heavily laden with moisture is blowing over the Province, as is the case during the rainy season, but it is required that both currents be present in different districts. To state the case roughly and very briefly, it is believed that the actual storm may be formed at the area of interaction by one of two causes. Either the moist wind may be forced upwards above the hot, dry current, when according to well known laws the mass of gas would expand and cool, and at once deposit a part of its moisture in the form of rain. This formation of liquid water from aqueous vapour will immediately set free a large amount of energy, which, perhaps, increases the ascen-

* Indian Meteorological Memoirs, Vol. I, p. 119.

sional motion; and this probably forms an important part in the development of the storm and of its well known energy. Or the north-westerly current which is blowing may suddenly overcome the resistance of the southerly current, and cool air from the higher regions of the atmosphere may force its way downwards to the earth's surface and cause similar effects. The formation, however, of these nor'westers appears to necessitate a considerable amount of air motion, and also that the air currents shall be of more or less opposite nature.

This, however, does not exhaust the possibilities of storms in India, and, in many cases, dust-storms, &c. are formed when there are apparently no opposing wind systems at work as previously described. Such storms usually form at considerable distances inland and over highly heated and dry land surfaces, and their formation is probably due to the intense heating effect of the sun's rays on an atmosphere more or less laden with dust and other solid particles. The immediate antecedent cause of the formation of such a storm may perhaps be found in an action which may be best described in the words of Sir George Airy, who states, "The atmosphere is a viscous gas, and it is only on this assumption that cyclonic phenomena and the phenomena of all rotatory storms in the hotter parts of the earth can be explained, and that in such storms there is a mass of hot air which, from the viscosity of its structure, is not able to rise up for a long time until at last it rises up with a burst." It is in fact only by some such action as this that many of the phenomena of hot weather storms in India can be explained. If we admit that, over a considerable tract of land, owing to the heating effect of the sun and the viscosity of the air, there is a decided increase of pressure, which, after accumulating for a time, is suddenly relieved, and that in consequence of this relief of pressure the highly heated air suddenly ascends, then the uprush will, directly the ascensional motion commences, assume a spiral movement, and there will be formed in the northern hemisphere a wind rotation probably against the hands of a watch, similar in fact to that sometimes observed in dust-storms and usually in tornadoes in the northern hemisphere. Though these storms can be understood so far, their enormous energy has not been well accounted for, though many theories and suggestions have been put forward.

Theories such as have just been very briefly and incompletely described are advanced to account for the classes of storms which are frequently met with in India during the hot season of the year, but, from time to time, perhaps once in five or ten years, the conditions which usually are only followed by ordinary nor'westers or dust-storms, but which are more or less violent in their nature, give birth to a whirlwind or tornado of extreme energy and destructive force. In the case of the

Dacca tornado under discussion, an ordinary nor'wester was actually in progress when the tornado suddenly appeared in close proximity to, if not in actual connection with, the storm, but still quite distinct from it, and moving in its own particular path. This would apparently point to the fact that the general conditions which produce nor'westers, or perhaps dust-storms, may with the addition of some cause or causes, possibly almost accidentally present, also generate tornadoes of a violent type. What such additional circumstances or causes are which determine the actual formation of the tornado, it is impossible at present to say, but it is fortunate for India that the combination of circumstances required is rare.

The conditions as to great contrasts of temperature and humidity previously referred to, and the passage of areas of barometric minima may be looked upon as predisposing causes only, but they clearly cannot be classed as proximate causes, for such predisposing conditions obtain very frequently indeed in India, and it is rarely that they are followed by tornadoes.

Tornadoes are also found in America to be formed frequently during still or almost calm weather, and there are accounts of observers having actually seen the formation and growth of a tornado taking place on an almost perfectly calm but sultry day.* This would perhaps point to some such action as described before in Sir George Airy's words being the possible explanation of their formation; and, if such is the case, any forecast of their probability from any regular or definite series of meteorological conditions would become impracticable, for it is manifestly impossible to say when any sudden uprush of heated air may take place over any large and highly heated area, or at what point such action might occur.

The above statements may perhaps be said to be confessions of an ignorance more or less complete of the subject of tornado formation, but such only are the facts at present known.

Meteorological Conditions in Bengal previous to the Tornado.—The meteorological conditions of the earlier parts of the year do not call for any particular comment. In fact, the phenomena of the formation and existence of a tornado are of such a brief and transitory nature that it would be useless to seek for anything like proximate or even predisposing causes in the meteorology of the previous months of the year; so that an extremely brief record will suffice.

January and February were months of the normal cold weather type in Bengal, and in March the usual rapid increase of temperature

* H. S. Whitfield, Tornadoes in the Southern States, American Journal of Science, 3rd Series, Vol. II, p. 96 and others.

took place, the mean temperature of the province at the end of March being nearly 10° higher than at the commencement. The winds blowing in the various districts were nearly normal in character; dry westerly and north-westerly winds were reported in the west and north-west of the province, moist south-westerly and southerly winds were blowing at the southern stations, and moist south-easterly and easterly winds at the eastern and at some of the northern stations. In consequence of the interaction between these wind systems, a considerable number of local storms or nor'westers occurred, principally about the middle of the month; these ceased about the 18th of March and weather became fine, but again on the 27th, without any particular change in the ordinary conditions, a series of storms set in, very local in character, but some of which were exceedingly fierce. One, if not two, of these storms appear to have been whirlwinds or tornadoes. One of them occurred in the Magura subdivision of the Jessore district, and Mr. F. H. Barrow, C. S., Magistrate of Jessore, describes it as follows:—

"I have the honor to report that at sunset of 27th March last, a hail-storm blew in the Magura subdivision and devastated the villages Barbhanga, Kukhila, Gobindpore, Nurandia, Ghoranach, Jagdal, and Dakurbhila. It is described as having risen in the shape of a whirlwind from Kalijir bheel about 2 miles to the south-east of Magura and blown right across the south over the villages in the order they are noted. It blew in a cyclonic form, throwing down almost all the huts and uprooting and smashing extensive bamboo topes and fruit trees, it is said by thousands. There was a large tank in village Ghoranach which supplied drinking water to the inhabitants of the neighbouring villages. This tank has been literally filled with falling trees and branches, and the water rendered undrinkable.

"Four persons died by the fall of trees and huts, and nearly 24 persons, chiefly women, have received hurt.

"The storm has caused great hardship to the inhabitants of the 7 villages named. They have lost almost everything they had, and have no shed to shelter them."

The following is a further note by Babu Kali Prasanna Sircar, Subdivisional officer of Magura.

"The tornado blew towards the south, inclining a little towards the east. It is said that two gusts of wind, one blowing from the east, and the other from the west, met together at Kalijir bheel, about 2 miles south of Magura, and then swept across the country. The area affected is about 7 miles in length and 1 mile in width, and the duration was about 10 minutes. The people say that the tornado blew in the shape

shewn in the sketch.* It was ushered in by a deep rumbling sound as of a continuous distant thunder and it lasted about 3 minutes."

On the same day, 27th March, an extremely violent storm took place in the Pubna district, which passed over the villages of Barenga, Kalayanpore, and many others. The storm is said to have blown from the north-west and crossed the Brahmaputra and Batabunda over to the district of Dacca. It seems to have lasted, according to the published accounts, about half an hour. Many huts and trees were thrown down and some pucca houses badly injured. More than 20 persons were killed and about 80 severely injured. No details as to this storm have been received from the District Officers by the Meteorological Department, the above facts having appeared in the daily papers, but, so far as can be judged by its destructive violence, etc., this storm also must have been a whirlwind or tornado, though probably not connected with the Magura storm.

From the 27th of March to the 4th April, again, the meteorological conditions of the province call for no particular comment, except that on the 1st there were storms in North Bengal, and on the 4th a few nor'westers were reported in Orissa and West Bengal. From the 4th to the 6th there was an almost complete absence of local storms, and weather appeared fairly settled. The character of the meteorological changes which took place in Bengal from the 5th to the 6th of April is shewn in the following small table :—

Observations taken at 10 *a. m. April 6th*, 1888.

Stations.	Pressure reduced to 32° and sea level in inches.	Change of pressure since previous day.	Maximum Temperature.	Minimum Temperature.	10 A. M. Temperature.	Humidity 10 A. M. Sat. = 100.	Wind direction.	Wind velocity in miles per hour.	Cloud proportion.	Rainfall.	State of weather for previous 24 hours.
False Point ...	29·848	− ·024	87·4	77·6	85·3	78	S.S.W.	11	3	Nil.	Fine.
Hazaribagh ...	29·764	− ·023	94·5	69·9	91·7	0	N.W.	12	0	Nil.	Fine.
Patna	29·758	− ·004	99·7	70·2	94·7	9	W.	7	0	Nil.	Fine.
Saugor Island ...	29·838	Nil.	90·2	80·0	85·9	78	S.S.W.	19	6	Nil.	Fine.
Calcutta	29·831	+ ·022	97·5	75·2	86·4	68	S.S.W.	4	0	Nil.	Fine.
Jessore	29·838	+ ·032	100·8	76·3	90·(	64	S.S.W.	3	0	Nil.	Fine.
Furreedpore ...	29·868	+ ·005	88·5	76·9	87·[illegible]	65	S.	5	0	Nil.	Fine.
Chittagong ...	29·897	+ ·032	88·8	74·3	86·(	68	S.S.W.	8	3	Nil.	Fine.
Dacca	29·820	+ ·012	94·1	77·0	86·7	70	S.W.	8	0	Nil.	Fine.
Mymensing ...	29·823	...	90·0	76·1	85·2	63	S.E.	6	2	Nil.	Fine.
Serajgunge ...	29·800	+ ·021	99·0	71·7	90·7	44	S.S.W.	5	0	Nil.	Fine.
Dhubri	29·801	+ ·059	95·6	69·7	84·9	44	W.S.W.	6	0	Nil.	Fine.
Bogra	29·777	+ ·030	100·3	71·8	94·5	21	S.W.	6	0	Nil.	Fine.
Dinagepore ...	29·756	+ ·020	99·1	65·7	96·3	11	S.W.	6	0	Nil.	Sultry.
Rampore Beauleah	29·790	− ·009	98·4	66·7	95·6	23	S.W.	4	0	Nil.	Fine.
Berhampore ...	29·810	+ ·018	101·2	72·3	94·5	18	S.S.W.	6	0	Nil.	Fine.

* The diagram given is very similar to the shape of an apple.

The observations contained in the above table, with those of a good many other stations, are charted on a small map (Pl. XXIV.) on which are drawn the lines of equal pressure reduced to sea-level, which are shewn by continuous lines, the lines of equal humidity in broken lines, and those of equal temperature at 10 A. M. by dotted lines; but in the last case the temperatures are not reduced to their sea-level equivalents, for the majority of stations which are shewn are in the plains of Bengal, and do not therefore differ very much in height above sea-level, and, for the purposes required in this paper, it does not appear that such a correction is necessary. The observations prove clearly that, so far as atmospheric pressure was concerned, the changes were very small, and did not denote that there was any particular disturbance going on in Bengal. On the previous day, the 5th, the observations taken over the whole of India for the India Weather Report had shewn that pressure was falling over part of Orissa and the neighbouring parts of the Central Provinces, while over the whole of Bengal and Behar pressure was rising. On the 6th April, or the day under review, pressure was falling decidedly over Chutia Nagpur and parts of Orissa, while it was still rising over the remainder of the Province, particularly in East and North Bengal. Owing to these changes, a shallow area of comparatively low pressure appears to have formed over parts of West Bengal and Chutia Nagpur, though the lowest pressures in the province were actually recorded in Behar and North Bengal. On this day also, the isothermal lines representing differences of 5° are very close to each other, particularly over parts of North Bengal, shewing that there were great contrasts of temperature over limited areas. The broken lines shewing equal degrees of humidity are also very close over East and North Bengal, and, while such stations as Berhampore, Rampore Bauleah, Bogra, Dinagepore, and the area to the west shew generally humidities below 20 per cent., only 50 to 100 miles to the east of this area, humidities of about 70 per cent. were generally reported.

The distribution of the humidity and the wind directions over the Province as laid down in the chart for the day (Pl. XXIV.) shew most clearly that two very distinct wind currents were principally affecting Bengal. There was an exceptionally dry westerly current blowing from the centre of India over Behar, Chutia Nagpur, and West Bengal, and even penetrating as far as North Bengal, for winds were more or less westerly with very low humidity at Bogra, Dinagepore, and Rungpore. At the southern stations, a strong and very moist southerly wind from the Bay of Bengal was blowing, giving, in combination with the westerly winds from Central India, a south-westerly breeze over considerable parts of the centre of the Province, while north-

easterly winds were blowing down the Assam valley, and reached as far as Julpiguri in North Bengal. The limit on this day of the area of the action of the moist southerly winds may be said to be defined by a curved line running through Balasore, Calcutta, Jessore, and Mymensingh; and near this line and to the north and west of it, the contrasts of temperature and humidity were exceptionally large.

The following table gives again some of the principal meteorological observations taken in Bengal on the morning of the 7th April 1888.

Observations taken at 10 *a. m. April 7th,* 1888.

Stations.	Pressure reduced to 32° and sea-level in inches.	Change of pressure since previous day.	Maximum temperature.	Minimum temperature.	10 A. M. temperature.	Humidity 10 A.M. Sat. = 100.	Wind direction.	Wind velocity in miles per hour.	Cloud proportion.	Rainfall.	State of weather for previous 24 hours.
False Point ...	29·815	– 033	86·9	77·6	85·3	74	S.S.W.	14	0	.	Dust Haze.
Hazaribagh ...	·716	– .048	98·5	72·8	92·2	8	S.S.W.	9	0		Fine.
Patna	·711	– .047	102·9	73·2	98·3	16	W.	5	0	...	Clear.
Saugor Island ...	·795	– .043	89·7	80·5	85·9	76	S.S.W.	22	4	...	Fine.
Calcutta	·767	– .064	96·5	77·2	86·9	70	S.W.	7	2	...	,,
Jessore	·773	– ,065	102·0	78·4	89 4	68	S.	4	0	...	,,
Furreedpore ...	·858	– .010	88·5	76·4	88·0	63	S.	5	0	..	,,
Chittagong ...	·873	– .024	87·9	75·5	85·7	65	S.	7	3	...	,,
Dacca	·779	– .041	94·5	76·2	86·7	72	S.S.W.	10	2	.	,,
Mymensing ...	·780	– .043	90·3	75·6	84·7	68	S.S.E.	5	5	...	,,
Serajgunge ...	·741	– .059	100·0	73·7	89·5	59	S.S.E.	6	0	...	,,
Dhubri	·740	– .061	96·7	67·8	84·7	59	Calm.	5	4	...	Clear.
Bogra	·710	– .067	101·9	74·6	91·5	58	W.S.W.	6	0		Hot wind.
Dinagepore ...	·703	– .053	101·1	66·2	99·8	13	W.S.W.	7	0	...	Very sultry.
Rampore Beauleah	·740	– .050	100·4	70·7	89·6	64	S.	5	0	...	Fine.
Berhampore ...	·738	– .072	103·2	75·3	90 4	63	S.W.	7	0		Foggy.

On this day, there was again only a slight change in the pressure, and the barometer fell by about 0·03″ to 0·07″ over the whole province. The most rapid fall of pressure took place at such stations as Calcutta, Kishnagar, Jessore, Berhampore, Serajgunge, Bogra, and Dhubri, apparently pointing to the advance of the feeble area of low pressure from Chutia Nagpur and West Bengal towards Central and North Bengal. The area of comparatively low pressure was, however, a feeble one, but it is shewn distinctly in Pl. XXV. by the shape of the isobars for the day, that for 29·75″ dipping down rapidly to the south and including a large part of the centre of the Province. There was no particular change of pressure at Dacca or at any of the neighbouring stations

in any way differing from the general atmospheric oscillation which was taking place over Bengal, and no indication of any kind was given of the possible formation of any violent storm over this area. So far then as the pressure indications go, it would appear that the extremely feeble comparatively low pressure area which on the 6th was over Chutia Nagpur and West Bengal was advancing slowly in a north-easterly or easterly direction, and it is certain that the pressure at some of the stations in the centre of the Province, particularly at Kishnagar or between that station and Berhampore, was distinctly low. At Kishnagar indeed the fall of pressure in the 24 hours preceding 10 A. M. of the 7th was 0·074 inch, while at Berhampore it was 0·072 inch.

A glance at Pl. XXV., representing the meteorology of this day, will again shew the very marked contrasts of temperature and humidity which existed over the centre and north of the Province, and particularly in North and Central Bengal, where high temperature with low humidity and low temperature with high humidity existed within a few miles of each other. Thus at 10 A. M. at Dinagepore temperature was 99·8° and humidity was 13 per cent., while at Rungpore, a few miles to the east north-east, temperature was 88·4° and humidity 45 per cent. At Nya Dumka temperature was 97·9° and humidity 13 per cent., and at Berhampore, a few miles to the east, temperature was 90·4° and humidity 63. It will, however, be noticed that this area of great contrasts of temperature and humidity had advanced much further north than it was on the 6th. In fact, when comparing the humidities and wind directions at the various stations on the two days, it is seen that on the 7th the moist southerly wind current had advanced rapidly over Central and part of North Bengal, and had either forced back the dry westerly wind before it, or had pushed its way under it, and thus on this day there is no doubt that the moist current from the Bay of Bengal made its influence felt as far as Berhampore, Rampore Beauleah, Bogra, Maldah, and Rungpore, but that it had failed to reach as far north as Dinagepore. This fluctuation in the area affected by these winds is unusually large and well marked, but, as will be seen subsequently, the observations of the 8th April shewed that this northerly advance of the moist southerly winds was purely temporary, and by the morning of the 8th the moist winds had been completely driven back to their former position. Such large oscillations as these point most unmistakeably to a most disturbed state of the atmosphere, and it will be remembered that, on the evening of this day, the tornado at Dacca happened.

The following table contains some of the principal meteorological observations taken in Bengal on the morning of the 8th April :—

Observations taken at 10 *a. m. April 8th*, 1888.

Stations.	Pressure reduced to 32° and sea-level in inches.	Change of pressure since previous day.	Maximum temperature.	Minimum temperature.	10 A. M. temperature.	Humidity 10 A. M. Sat. = 100.	Wind direction.	Wind velocity in miles per hour.	Cloud proportion.	Rainfall.	State of weather for previous 24 hours.
False Point ...	29·768	−.047	86·4	78·2	86·8	72	S.S.W.	21	0	...	Dust Haze.
Hazaribagh ...	·761	+.045	101·3	70·5	85·6	4	W.	18	0	...	Strong wind.
Patna ...	·695	−.016	104·9	73·2	90·6	8	W.	6	0	...	Clear.
Saugor Island ...	·767	−.028	89·7	81·5	85·4	79	S.W.	27	0	...	Fine.
Calcutta ...	·733	−.034	93·5	72·7	92·4	22	W.S.W.	6	0	...	,,
Jessore ...	·754	−.019	99·1	74·7	92·2	40	N.W.	4	0	...	,,
Furreedpore ..	·865	+.007	88·5	77·9	87·5	61	S.	6	0	...	,,
Chittagong ...	·803	−.070	87·7	74·0	83·4	76	S.S.E.	9	0	..	,,
Dacca ...	·714	−.065	92·9	75·2	86·7	75	S.W.	12	1	0·36	Tornado.
Mymensing ...	·699	−.081	90·2	73·4	86·6	67	S.S.E.	8	3	...	Fine.
Serajgunge ..	·676	−.065	101·3	73·7	89·5	51	W S.W.	7	0	...	,,
Dhubri ...	·665	−.075	99·4	69·2	84·6	60	N.N.E.	7	1	...	Clear.
Bogra ...	·660	−.050	104·3	73·8	93·1	27	W.	6	0	...	High wind.
Dinagepore ...	·709	+.006	100·6	69·1	95·8	10	W.S.W.	10	0	...	Very sultry.
Rampore Beauleah	·680	−.060	101·4	69·7	93·6	27	S.W.	4	0	...	Fine.
Berhampore ...	·712	−.026	104·7	74·3	93·5	17	W.S.W.	5	0	...	,,

It will be noticed in these observations that there had been a decidedly rapid fall of the barometer at Rampore Beauleah, Mymensing, Serajgunge, Dhubri, and Bogra, while at Saugor Island, Jessore, Calcutta, Berhampore pressure had fallen only slightly. The slight area of comparatively low pressure which was in Central Bengal on the 7th April appears to have again advanced in a north-easterly direction and to have slightly intensified, and on this day a very distinct low pressure area existed in North Bengal, and was represented by such stations as Rungpore, Bogra, Serajgunge, Mymensingh, and Dhubri. The marked contrasts of temperature and humidity still existed over the north and centre of the Province, but scarcely to such an extent as on the 7th, and the lines in Pl. XXV. shewing the increase of temperature by 5° and of humidity by 25 per cent. on this day are still rather close. The most important feature is, however, the change which is seen in the condition of the centre of the province when the humidity and wind directions are considered together, and, as already indicated, the moist southerly wind which had advanced rapidly over the country from the 6th to the 7th had been forced back between the 7th and the 8th with apparently

more than equal rapidity, and in fact the southerly winds had been pushed back much further than they had previously advanced, for on this day their action was confined only to the area to the east of a curved line represented by such stations as Saugor Island, Burrisaul, Fureedpore, Serajgunge, and Dhubri. It is therefore clear that there must have been a most unusual and rapid increase in the strength of the dry westerly wind current on the 7th to have overcome the resistance of the strong southerly current in such a complete manner, and the actions of these opposing winds seem to be by far the most important facts in the meteorology of the period, 6th to 8th of April, during which the tornado was formed.

These changes in the areas affected by either the very dry westerly or the very moist southerly current are best shewn by placing in a table the humidities recorded at 10 A. M. at the various stations affected on each day from April 6th to the 9th inclusive.

Table shewing the Saturation of air with moisture.
Complete saturation = 100.

District.	Station.	April 6th, 1888.	April 7th, 1888.	April. 8th, 1881.	April 9th, 1888.
Behar ...	Motihari ...	14	16	6	6
	Arrah	13	64	10	11
	Bankipore ...	9	16	8	11
Chutia Nagpur ...	Hazaribagh ...	0	8	4	5
South-West Bengal ...	Calcutta ...	68	70	22	13
	Burdwan ...	45	60	14	10
	Berhampore ...	18	63	17	15
	Jessore	64	68	40	50
East Bengal ...	Chittagong ...	68	65	76	79
	Burrisaul ...	72	73	73	56
	Fureedpore ...	65	63	61	32
	Dacca	70	72	75	50
	Mymensingh ...	63	68	67	18
North Bengal ...	Bogra	21	58	27	14
	Rampore Beauleah...	23	64	27	18
	Maldah... ...	31	49	26	27
	Dinagepore ...	11	13	10	7
	Rungpore ...	16	45	45	21

The figures contained in this table may be more clearly grouped into three districts: first, that to the west and north of the province, second, that to the east and south, and, third, the district in the centre of the province dividing the two. Arranged in this way the figures shewn in the following table are obtained, and it will be seen that over the third of these divisions, or over the area through which the barometric minimum

passed and to the south-east of which the tornado was formed, there were from the 6th to the 8th the most striking and excessive changes in humidity.

District.	Average Humidity—Saturation = 100.			
	April 6th.	April 7th.	April 8th.	April 9th.
A.—Stations in Behar, Chutia Nagpur, and North Bengal acted on by dry wind current	16	40	18	14
B.—Stations in South and South East Bengal	64	67	54	39
C.—Average of Stations, Berhampur, Rampur Beaulah, and Bogra representing an area in a N. E. direction over which apparently the barometric minimum passed and to the south east of which the tornado was formed	21	62	24	16
Difference between B. & C. ...	43	5	30	23

These rapid changes of humidity necessitate equally rapid changes in the air currents affecting the areas, and it is therefore clear that, in Central and North Bengal, or to the north north-west and west of the position in which the tornado was formed, or at all events in which it made itself felt during the period 6th to 8th April,

1. There were rapid changes in the areas affected by two wind currents of almost opposite nature.

2. There were great contrasts of temperature and humidity at neighbouring stations over the same area.

3. There is evidence to shew that there was a shallow area of comparatively low pressure, or a barometric minimum, which passed in a north easterly direction through the centre of the Province from the 6th to the 8th April, or at the time of the formation of the Dacca storm. In other words, the Dacca tornado was formed to the south-east of the track of a feeble low pressure area, and to the south-east of great contrasts of humidity and temperature, as is always found to be the case in America by Mr. Finley and others. But, as before stated, these can only be predisposing causes, and what the immediate cause of the formation of the storm may have been it is impossible to say; and, though it is conceivable that the violent fluctuations of the opposing air currents above referred to may be in some distant way connected with its causation, or with rendering the formation of such a storm extremely probable, yet it is clear we are far from having arrived at its actual cause.

The excellent exhaustive description of the tornado at Dacca which follows this paper is contributed by Dr. A. Crombie, Civil Surgeon of that place. The track of the storm as given by Dr. Crombie shews that the statement of the meteorological observer at Dacca that the storm passed through the compound of that observatory, which was published in the Calcutta Gazette in the Report on the Meteorology of Bengal for the week ending the 13th of April, was incorrect; and it is clear that the storm track was some little distance from the meteorological observatory.

The storm in its destructive effects seems to have been strictly confined to a very sharply defined area, and not to have had even an outer circle of very strong winds, for Mr. E. F. Mondy, Professor of Science, Dacca College, writes :—

"There was nothing of a remarkable nature to indicate its coming. One of the usual not very violent storms was known to be coming, but nothing more. Nor were there any very violent winds outside of its track. I live on the river side and was in my verandah the whole while, not 100 yards from its track on the river side, the river running here about W. 30° N., and not a stone's throw from Edward's house (one of those injured though apparently not quite in the track of the storm), which lies N. 20° W. from here, but the wind even at this short distance was by no means strong. Yet while I was in the verandah and watched the approach of the storm from the other side of the river, the whole of the tremendous havoc was done just to the N. W. of us."

The track of the tornado, which is most fully described in Dr. Crombie's paper and is also illustrated by diagrams, appears to have been mainly in an east-south-easterly direction while passing through Dacca, but if Dr. Crombie's surmise is correct that the same tornado afterwards visited the Moonsheegunje District, then its path must have changed to south after rising from the Sankari Bazar. This may undoubtedly have been the case, but there is however nothing impossible in the counter suggestion that the tornado which visited the Moonsheegunje District was a second one. In America, eleven separate tornadoes within a comparatively small area have been known to occur on a single day, and thus it is quite possible that, with the favorable conditions for the formation of such storms which must have obtained in the Dacca District on the 7th of April, two or even more of such storms might have originated. The time at which the storm visited the Moonsheegunje District and the known rate at which the Dacca storm was travelling perhaps favour Dr. Crombie's view.

It is also desirable in connection with the subject of tornadoes in Bengal to place on record an account of another small storm which

visited the Hooghly District on the evening of April 27th. The small town which was visited is close to Serampore, and only about 16 or 17 miles north of Calcutta. The account is written by Mr. F. W. Duke, C. S., Subdivisional officer of Serampore, and the report was submitted to Mr. Toynbee, Magistrate of Hooghly, by whom it was communicated to the Meteorological Department.

The following is Mr. Duke's letter, which is dated April 28th, 1888.

"I have the honor to report that early this morning I was informed by the Police that yesterday evening Bhudressur had been visited by a tornado, and that the Police outpost had been blown down and much damage, accompanied by loss of life, had been done.

"Accompanied by the Assistant Superintendent of Police I proceeded to Bhudressur, and found that a tornado apparently under the form of a whirlwind from right to left had entered the south-eastern part of the town from the river about 8 o'clock yesterday evening. It proceeded north-west by north, and having travelled about 1½ miles finally left north-east about the northern part of Bhudressur disappearing in the river—as it had come. The breadth of its course was about 200 or 300 yards on land from the shore and the centre and point of greatest violence about the line of the river-bank near the Gunge. It was stated that the tornado was preceded by a booming sound: its total duration is estimated at from 3 to 6 minutes. The violence of the wind must have been inconceivable, many large trees were blown down, and the Grand Trunk Road was completely blocked by them this morning. Many thatched houses, probably some score, were blown down—the tiled part of the town was completly stripped, and the streets were full of fallen tiles. In the town four people were killed by the falling of houses, and many more or less injured. Both the regular outpost and the Police barracks entirely collapsed, all the Police papers and records being buried in the outpost. Most of the constables were in the barracks when they fell in, but all succeeded in struggling out, scratched and bruised it is true, but without broken bones.

"Along the river bank, however, the force of the wind had been most tremendous. In several cases boats of 500 maunds' burden had been picked out of the water and thrown over to the bank. I saw a shattered dinghi which had been blown up on to a tree which had first been partially blown down. Another dinghi had been picked out of the water, blown across 15 or 20 yards of chur, and on to the upper part of a high pucca-ghat. A 500 maund boat had been docked for repairs and the manjhis had built a temporary shelter behind it, the boat was lifted by the storm, turned on end and thrown over the shelter, crushing it to nothing and killing two men in it, the boat itself being crushed out

absolutely flat by the violence of the fall. In another case a large boat was blown up the river-bank, and is now blocking a road within the Gunge. In all as far as I could ascertain, 7 persons had been killed, 3 were missing apparently in the river—nine persons were seriously injured; of these eight were put in a boat and brought to Serampore, and an unascertained number had sustained slight injuries. The material damage I have as yet no means of estimating; when accurate figures are available on mortality, injuries and losses, I will forward them. Temporary accomodation must be provided for the Police. The outpost and barracks are utterly laid waste, and quite beyond repair."

PART II.

An account of the Dacca Tornado of the 7th of April, 1888.
By Dr. A. Crombie, *Civil Surgeon of Dacca.*

There can be no question that the storm which wrecked a portion of Dacca on the evening of the 7th of April, 1888, was a tornado or whirlwind. The evidences of its nature are quite conclusive. They consist in observations of the directions in which objects which it encountered have been thrown down or distorted. The objects which give the most unmistakable evidence are walls running at right angles to the track of the tempest, trees, especially plantain trees, the pinnacles of mats and masjids, and kutcha huts; and the experiences of persons who were stationed at or near the vortex as it passed over them.

A tornado is a whirling wind rotating at an enormous speed, and advancing rapidly at the same time, along a more or less straight line. For convenience of description, such a whirlwind may be said to have four radii, an anterior in advance of the vortex, a posterior behind the vortex, and two lateral radii at right angles to the centre line of the track of the storm. All objects situated directly in the centre line of the track will be driven in a direction at right angles to that line, in one direction by the anterior radius, and in the opposite direction by the posterior radius, while objects situated near the sides of the track will be carried or driven forwards on one side, and backwards on the other, in relation to the track of the tempest. One of these lateral radii, that which carries objects in the same direction as that in which the tempest is advancing, may be called the advancing lateral radius, while the opposite which drives objects in the opposite direction may be called the retrograding lateral radius.

In the diagram shown as Fig. A., Pl. XXVII., AB is the line taken by the vortex in its advance, C is the vortex, the circle FLEK represents the whirling of the wind round the vortex C. The arrows indicate

the direction in which it is rotating, CE is the anterior radius, CF the posterior radius; CL is the advancing, and CK the retrograding lateral radius. It is obvious that all objects at E will be blown to the left, all objects standing at F will be blown to the right of the line AB, while all objects at L will be driven forward, and all at K, backwards; it is also obvious that, as the circle moves up the line AB, they will encounter first the force of the wind at E, and be knocked over to the left, and only those which have withstood the wind at E will encounter the wind at F as the tempest advances, and only these will be driven to the right. If the line AB happen to be an unprotected stone wall, it is clear that, as the storm proceeds, the whole of that stone wall will be thrown to the left by the wind at right angles to the anterior radius, none of it will be thrown to the right by the wind at F, because it will probably have previously been demolished by the wind at E. If, however, the wall be placed in the line KL at right angles to the line of progress of the storm, all to the right of the vortex will be thrown down forwards by the advancing lateral radius of the whirlwind, while all to the left will be thrown down backwards by the retrograding lateral radius. This was clearly indicated by the storm of the 7th of April. It struck the Buckland Bund nearly at a right angle about 90 paces above the Nawab's palace. Here there was a garden having a south and a north wall both running parallel to the Bund, and therefore at right angles to the line of the advancing storm. The south wall, next the Bund, was low, but topped by an ornamental cast iron railing, and the north wall was about 10 feet high. To the east of a certain point, the cast iron railing on the south wall was driven into the garden by the wind on the advancing lateral radius CL, while all to the west of the same point was driven on to the Bund by the retrograding wind on the radius CK. The north wall was treated in the same way. All to the east of a certain point, directly opposite the point on the south wall, was driven forwards into the compound of the house being built for Sulimulláh Miya, while all to the west of that point was driven by the retrograding lateral wind backwards into the garden. The corresponding points of these two walls showed precisely where the vortex of the tornado passed over them, and fixed the track of the vortex at this part of its course; and the way in which these two walls fell was alone sufficient, if no other evidence had been forthcoming, to prove that this storm was a tornado, and also that the wind was circling from right to left, as in the diagrams I have drawn. The action of the storm on this part of the Buckland Bund is shown in Fig. B., Pl. XXVII. Unfortunately other evidence was only too plentiful. On the opposite bank, the storm had, before crossing the river, burst through a belt of trees, some 300

yards in breadth in which was concealed a Muhammadan village. All the trees on the east side of the track of the tempest were lying directed towards the river in a northerly direction, all on the west side were directed southwards, inland, away from the river. The former had been broken or uprooted by the advancing lateral radius, the latter by the retrograding lateral radius. In the centre of the track, where they had been exposed to the anterior radius, and afterwards to the posterior radius as well as to the inner lateral radii, nothing but stumps were left; for it is clear that, while all objects outside the lines MN and OP (in Fig. A., Pl. XXVII) will be exposed to only one wind force, an advancing one in the case of OP, or a retrograding one in that of MN, those within those lines will be exposed to three out of the four wind forces in action. Thus, an object situated in the line RS will be first thrown to the left by the wind forces after they have passed the line CE, then subjected to a retrograde force on the line CK, and will afterwards be tossed to the right by the wind forces approaching CF. It was thus that the tornado ground its way through the Nawab's palace and through the masonry houses between his palace and the main street of the town.

For these reasons, when the tornado is passing over masonry buildings, it will appear as if most of the destruction near the centre of the track had been done by a wind blowing from right to left, because the wind forces at right angles to CE, the anterior radius, are the first to come in contact with them. They are immediately thrown down to the left and remain there undisturbed by the subsequent rotatory winds which pass over them. So it is with plantain trees, which do not snap across, but bend and break and lie down flat, retaining their connection with the root by a short stump. But with hard wood trees, and with kutcha huts and furniture, it is different. They are first carried to the left by the wind force near the anterior radius, and afterwards lifted and carried from left to right by the forces on the posterior radius. Thus, it was not uncommon for the roof of A's house to be carried into B's compound, and immediately afterwards B's roof to be lifted and deposited in A's compound. So in the Nawab's house an almirah in one room was carried through a doorway into another room, and from the latter a writing-table was carried through another doorway into the former room. These interchanges only take place near the centre of the track.

The tornado of the 7th of April began its destructive course at the extreme west end of the Municipal limits. Its exact method of commencement will be described further on. Here the houses are built on an old river bank, the bank of the old bed of the Buriganga, which at this season is here a mere khal. This old river bank is continuous in a nearly straight line with the present bed of the Buriganga, which now

approaches the town at the old Muhammadan Fort, the Lalbagh, just above the Water-works, at an obtuse angle to its old course, which was nearly straight from Hazaribagh on the west to Fatula a village 6 miles down the Narainganj road on the south-east. At the extreme west end of Hazaribagh is a mosque, Fakirni-ka-masjid. From this mosque a slightly sinuous road runs as far as the Lalbagh at an average distance of 300 feet from the old river bank. There are houses on both sides of the road, but at first they are chiefly between the road and the river bank. They are nearly all mat huts, the only masonry buildings being mosques: for this part of Dacca is Muhammadan. Afterwards, as the road runs successively through the mohullas called Inayatgunj, Nawabgunj, and Amligolah, pucka houses become more and more numerous, and in Amligolah, which is close to the Lalbagh, the majority of the houses are of this nature, and the inhabitants are mostly Hindu.

The first clear signs of the rotatory nature of the tempest occurred in an orchard to the north-east of Fakirni-ka-masjid, and close to it on the north side of the road referred to. Here there are remains of a clump of plantain trees thrown down and twisted in all directions clearly showing that they were in the vortex itself. Around this clump of plantains there was a fine old plantation chiefly of mangoes and jacks. The branches of all the trees to the north are broken off and thrown to the west, those on the south are thrown to the east, and several of the largest of them are uprooted bodily, and are now lying prone in the same directions, showing that even here the storm was already, in the very beginning of its manifestations, one of great violence. The masjid itself had only a few bricks disturbed, and the lie of the broken trees to the south-west of it was towards the north-east.

From this point to the north-east of Fakirni-ka-masjid, the vortex travelled in a south-easterly direction, crossing the road at an acute angle, and from that point continued its course between the road and the old river bank destroying every kutcha hut in this portion of Dacca. All the indications given were as above. Everything to the right of the vortex, that is, on the river bank itself was broken and laid low in a forward direction towards the east. There the advancing lateral radius was at work, while, on the road and to the north of it, all the indications were in an opposite direction, the work of the retrograding lateral radius. Between the river bank and the road, where the winds on the anterior and posterior radii were at work in opposite directions, there was mere confused destruction.

As the whirlwind passed eastwards along Inayatgunj, it gradually edged more and more towards the old bed of the river. This was probably due to the greater resistance offered to the forces on the left of

the line AB (Pl. XXVII., Fig. A.) than to those on the right. This was also the direction in which it originally started, but the continued resistance on the left no doubt helped to force it more and more to the right.

The storm passed well to the right of the pucka house of Babu Kailash Chandra Dás, a Municipal Commissioner, which was not disturbed, and, at the Elephant ghat below the Philkhana, the vortex was actually down in the old bed of the river. The road from the Philkhana to the Elephant ghat here crosses the track of the tornado at a right angle. On the west side of this road, on the old bank of the river, is a small Hindu temple, and there stood a tall Jagarnath Car; along the west side of the road was a brick wall. The brick wall and the Jagarnath Car were thrown down to the west, and the east corners of the temple were torn away, and the bricks thrown to the west into the compound, clearly showing that they had been caught by the retrograding lateral radius, and that the vortex was therefore to the right or south of them as in the diagram, Pl. XXVII., Fig. C. At this point of its course, the Khedda Sergeant's house was beyond the influence of the tornado, and the houses on either side of the road leading from Hazaribagh were undisturbed, but, on a spur of land lying to the south of the old river bed, the branches of trees and the plantains were broken and lying eastwards, as they had been caught by the advancing lateral radius of the whirlwind.

At this point of its course, the tornado bade fair to pass out into the open maidán lying to the south of Nawabgunj, that is to say, in the direction of least resistance, its vortex being already in the old river bed. But it is evident that a great barometric depression had formed to the north of its course. This was no doubt due to the constant sucking action of the wind forces on the retrograding (left) lateral and the posterior radii. It is clear, I think, that there must always be increased barometric pressure to the front of a tornado and on its advancing radius, and a barometric depression outside the retrograding and posterior radii and behind it in its track. However that may be, it is evident that, immediately after passing the Elephant ghat, there was a great barometric depression to the north of the whirlwind, for the vortex suddenly moved to the left (north), and at the same time a great hurricane from the north crashed through the trees, from a point to the east of the Philkhana, and joined in the revel of the tornado, the vortex of which was now near, if not on the main road through Nawabgunj.

The evidences of this great indraught are quite distinct. As you drive from the Lalbagh to the main gate of the Philkhana (Elephant depôt) by a road which is roughly parallel, but 600 yards to the north of, the path of the tornado, there are all along signs of a high wind which

was directed towards the south and west, but all at once you come upon evidences of a much more violent wind which had no westing in it, one which not only broke the high branches of trees, but uprooted huge peepuls and mangoe trees, and tore its way in a distinct track down south towards the tornado, just after it passed the Elephant ghat. This hurricane from the north of which I write was not more than 60 paces across, and was very local. It was altogether to the east of the Philkhana, where nothing was disturbed. It was curious to see the little low kutcha huts where the mahout's live, standing about, within the Philkhana enclosure, while 200 yards to the east a large solitary gáb tree was overturned, and a huge uprooted peepul tree blocked the road, and there were marks of devastation away everywhere in a track towards the south.

After the occurrence of this indraught from the north, the vortex passed along, or close to, the main road through Nawabgunj eastward. Soon it began to encounter on its left front the pucka houses of Amligolah, and from the resistance they offered to the anterior and retrograding radii, it again began to edge towards the right, passing however between these houses and Ram-Shaha's mât. This mât was taken by the advancing lateral (or right) radius, and two of its pinnacles were thrown down; those on the north-west and south-west corners. They were thrown south-east and east by north respectively. The finials of the two remaining pinnacles were bent south-east and south-east by south, but the terminal finial of the main spire at a height of about 60 feet was bent nearly due east, showing, I think, that the vortex was at this part of its course not perpendicular, but sloping backwards and towards the north-west.

From Ram Shaha's mát, the tornado continued to edge towards the south, till the vortex at last, just before reaching the Lalbagh, passed again on to the maidán. Up to this point the tornado does not seem to have had power to destroy pucka masonry buildings. So far it had only laid low all kutcha huts in its course, broken and uprooted trees, carried away the pinnacles of mosques and temples, and leveled kutcha pucka walls. It had only managed to dislodge a few bricks on the most exposed corners of masonry buildings. But as soon as it passed on to the maidán to the south of the Lalbagh, and was so freed of the obstruction offered by these obstacles, it seems to have rapidly accumulated additional force, sufficient before the vortex had passed the east gate of the Lalbagh for its retrograding lateral radius to knock down a portion of three of the police barracks, built high on the south rampart of the old fort, killing one and severely wounding twelve constables by the falling of masonry and beams.

Nearly opposite these three barracks which were destroyed by the retrograding lateral radius, two up-country coolies had been engaged in making a trench, running north and south, about six feet deep at the south end, near the river, but open, from the sloping of the ground, in the direction of the Lalbagh. They were close to the south end of the trench when the tornado came upon them, like a sudden hurricane from the south. They jumped down into the trench and crouched down for shelter, when in an instant, the wind blew with equal violence from the north, and hove a brick up the trench from the direction of the Lalbagh, inflicting a ghastly wound on the head of one of the coolies. From the directions in which the wind blew, the vortex must have passed over this trench, and this fixes its position at this point of its course.

The vortex now passed on to the river. The right or advancing radius did not reach the opposite bank at Haslee, but the left or retrograding radius kept sweeping along the river front as far as the Purana Kuttra. Close to the water-works, the Commissioner's Steamer, the "Linnet", and the police steam-launch, the "Marion," were anchored and made fast to the shore. The "Linnet" was unroofed; the "Marion" carried away from her moorings, a short distance up-stream, and sunk in 42 feet of water. This was obviously the work of the retrograding radius, and the resistance offered to this radius by the river bank and the pucka buildings on it continued to push the vortex more and more to the right, and it finally reached the opposite (south) bank at Jinjira Hath, which was promptly demolished and set on fire.

From Jinjira Hath, there is a road leading south-east to the village of Subadiya about a mile distant. This road was nearly in the direct line of the tornado, as it crossed the river from the south of the Lalbagh, and it followed it, making a track straight in the direction of Subadiya. This road is raised, but passes along a shallow depression or valley, sheltered on the south by high trees, and on the north by the belt of trees on the (south) bank of the Buriganga. Just as it entered on this course, the vortex passed over the new pucka masonry house of Abdul Bipari, and simply ground it to pieces, killing the owner and severely injuring three persons sitting with him at the time. The manner in which it treated this building is conclusive that the forces of the whirlwind had become greatly more intense than they were to the west of the Lalbagh.

From Abdul Bepari's house, the tornado made straight for Subadiya, running at an acute angle inland from the river, and at this moment Dacca lying on the opposite (north) bank of the Buriganga seemed safe, and Subadiya doomed. But before reaching this village it had to cross an open maidán stretching away to the south. Here it appears to have

encountered a strong current of air blowing up this maidán from the south; for no sooner did the tornado enter on this maidán than it abruptly altered its direction, wheeled nearly at a right angle to the left, crashed through the belt of trees between it and the river, and made for the palace of the Nawab on the opposite side.

On the opposite side it struck the Buckland Bund, opposite the private apartments of the Nawab. The exact position of the vortex is determined, as I have already said, by the points of the two walls of the garden intervening between the Bund and the palace, where the railing and wall were thrown down in opposite directions as previously described. A line drawn from these two points shows that the vortex was here directed north-east towards the middle of the western verandah of these private apartments. When the vortex reached that point, the whole of the advancing lateral radius was engaged in unroofing the south verandah of these apartments as well as that of the Ahsanmunzil to the right. The opposition offered by these high buildings to the right or advancing radius retarded this part of the whirl, with the effect that the vortex swung round to the right to the open space behind the Ahsuni munzil, and started off nearly due east in the direction of the Sankar-bazar and the Commissioner's house. As the vortex swung round behind the Ahsunmunzil, it passed over the inner apartments, which were gutted by the retrograding and posterior radii. As the vortex left the open space behind the palace, it had the Nawab's offices close on the right. These were demolished by the advancing lateral radius, while the retrograding radius played with the roof of the stables, and blew the top off the Nabatkhana over the main entrance from Patuatoli.

From the point where it left the Nawab's premises, the vortex worked low among the houses between it and the top of the road leading from the main street to J. P. Wise's house; leaving a track of confused destruction, as if from a prolonged bombardment. It was here that Jagabandhu Ray Bahadur was killed by the falling of his house, yet in the midst of this confusion of demolished houses, levelled walls, and twisted and broken trees, and the remains of kutcha huts, there is standing safe, close behind the Nawab's school-house, which was partly wiped out and wholly wrecked, the residence of one Bahadur Bepari, with its ornamental plaster mouldings, only a little bespattered with mud.

On reaching the main street close to Kabiraj's lane, the anterior radius seems to have become entangled in the narrow lanes and high houses of Sankari bazar, and the vortex to have risen suddenly into the air. The houses in this part of the town are two and three stories high, and only the upper stories are seriously damaged, though all the kutcha huts and many of the low kutcha-pucka walls are thrown down. From

this point the tornado seems to have passed high into the air, making only a final dash downwards at the Municipal Secretary's bath-room and one or two trees in the kachari gardens, the College, and in the Commissioner's compound. The last indications given are those of its anterior radius, and show it as departing in a north-easterly direction. The exact track of the tornado as it passed through Dacca is shewn in Pl. XXVIII., and a more detailed map of that part of its track in which the greatest amount of damage was done is given in Pl. XXIX.

In no part of its course did its breadth exceed 200 paces; where it struck the Buckland Bund it was only 180 paces broad. It travelled altogether over a distance of only $3\frac{1}{2}$ miles. Its rate of progress is not easy to ascertain. Nawab Ahsanullah tells me that he had been watching the progress of the "Nor'-Wester" all the evening; when, about 7 P. M., a servant came and informed him that there was a very peculiar appearance in the west. He went to the west end of the south verandah of the inner apartments, and there saw what looked like a glowing cloud in the direction of the Lalbagh. He stood looking at it for about three minutes, during which time it seemed to be stationary. He then went inside, where he had not been two minutes before the storm was on the house. Supposing the tornado had reached the Lalbagh when he left the verandah, and that it was three minutes before it reached the Ahsan-manzil, and that the route followed by the tornado was a mile and a half during that interval,—the rate of progress would be one mile in two minutes or 30 miles an hour. The Serang of the "Star of Dacca," who watched it from the time it crossed from the direction of the Lalbagh till it struck the Nawab's palace (the "Star" being anchored within the angle described by the tornado between these points), speaks of its having travelled with great rapidity. On the other hand, Khajeh Amirulla, who witnessed its progress over the same distance, estimates the time at 10 or 12 minutes, but admits that it may have been less. I myself saw from the Club verandah a low black cloud passing rapidly over the houses to the west in a north-easterly direction, and I estimate that its progress was not faster than that of a train on the Eastern Bengal State Railway, that is about 20 miles an hour. We have, however, considerable unanimity as to the period occupied by the storm in passing over any given spot: almost every one says it did not occupy more than a minute and a half. Considering the excited state of mind of those over whom it passed, this estimate may I think be safely cut down to one minute. Taking the distance between the extreme front of the anterior radius and the subsidence of the violent gusts which followed in its wake as 300 yards, we arrive at a rate of progress of a mile in $5\frac{1}{2}$ minutes nearly, or roughly 12 miles an hour.

The force of the wind rotating within the tornado is difficult to estimate. There is no doubt that it was very great. What the wind did when it came upon a pucka house standing at right angles to the course of the tornado, and caught by one of the lateral radii, was not at once to blow down the front wall, but to blow in the doors and windows, and then to lift off the terrace roofing, and blow out the back wall, thus leaving the beams supported only on the top of the front wall. Now there is evidence to show that in such cases the force of the wind blowing through the house, after the back wall had fallen, was sufficient to prevent the unsupported beams from falling for a perceptible time. To this fact Mr. Kelsall and Khajeh Amirulla owe their lives. Mr. Kelsall was in the Nawab's office when the right radius of the tornado caught it and blew the back wall into the street. The unsupported beams remained standing out like flags, long enough after the wall was blown out to enable him to make his escape before they fell. Mr. Kelsall's movements were no doubt very rapid on this occasion, and they were accelerated by the violent wind propelling him in the direction where lay his safety. On the other hand, Khajeh Amirulla was sitting in a small pleasure-house close to the Buckland Bund watching with great interest the roaring cloud bursting on the Bund, the true nature of which he did not understand, when, in a moment, the house was caught by the retrograding radius and demolished. A heavy beam fell on his shoulder; but fell so slowly and gently, owing to the force of the wind underneath it, that it felt like a soft but firm hand pressing him down to the ground. He remained under that beam for three quarters of an hour before he could be dug out. His companion was killed.

The persistency with which eye-witnesses declare that the cloud accompanying the whirlwind glowed cannot be overlooked. The men at Hazaribagh where it began its destructive course were not to be moved from their assertion, that when it first came upon them it glowed with a dull red lurid glare "like a smoky lamp chimney on fire." Khajeh Amirulla, who watched it with much interest, is perfectly clear in his statement that, as it approached him from the opposite bank of the river, it resembled a balloon in shape, and seemed to be lit up with a "reflected light," and that, at the narrow neck, it kept throwing out a body of fire on either side, as in the accompanying sketch, which is a facsimile of his own drawing (Pl. XXVII., Fig. D). The Nawab Ahsanulla and others also speak of its being accompanied with "balls of fire" proceeding at a great speed. On the other hand, nothing is so certain as that no one who was in the course of the tornado presented any appearance of having been burned. The injuries received were all of the nature of contused, lacerated, and punctured wounds, and simple

and compound fractures. In not one instance was there a trace of scorching. Mr. Kelly, the Resident Apothecary of the Mitford Hospital, on whose statement I put much reliance, is equally clear that the cloud, as he saw it, did not glow, and the appearance, as I saw it (but this was probably only the wake of the true tornado), was a low dark unilluminated cloud, throwing out sparks of fire, which were no doubt merely burning embers caught up and carried along by the storm. One of these was undoubtedly of this nature, for it was carried burning into Mr. S. J. Sarkies' verandah, where he crunched it out with the heel of his boot. These were no doubt the "balls of fire" noted by the Nawab and others. The appearance described by Khajeh Amirulla of a body of fire rushing out from below is more difficult to account for. The fires which followed its course in many places do not require the assumption of any fire connected intrinsically with the tornado itself, for the people had just finished cooking their evening meals, and were about to sit down to eat it when the storm burst upon them. The embers from the fires with which they had been cooking were no doubt caught up by the whirlwind and carried along with it, and thatched houses, blown down over these fires, would instantly take fire.

I am told that numbers of large fish were found on the Buckland Bund after the storm, and there is no doubt that they along with much water were caught up by the vortex as it crossed the river. The water thus taken up, circling with the dust of the whirlwind, was worked into a soft mud, and one of the most remarkable phenomena of the storm was the way in which all objects within the influence of the tornado were plastered with a wash of liquid mud. It covers all walls to a depth of nearly one-eighth of an inch, it matted the hair, coated the skin, and was ingrained in the wounds of the injured.

The noise accompanying the progress of the tornado has been variously described. It was compared by the Engineer of the Water Works and by Khajeh Amirulla to the letting off of steam. It was this sound which first attracted the latter's attention, and he put his head out of window to see what steamers were letting off steam at that time of the evening. It was then that he saw the storm breaking on Jinjira half a mile up stream on the other bank. The sound which I heard from the Club verandah in no way resembled the letting off of steam. It was a low sustained rumbling. I think that the discrepancy is capable of reconciliation. What they heard was, besides the noise of the reverberations of the tornado itself, the comparatively shrill sound of the storm crashing through trees and kutcha houses west of the Lalbagh, and on the opposite side of the river. What I heard was the sound of falling masonry, along the track of the storm from the Nawab's palace

to the Sankari bazar. As soon as the storm cloud passed, there was an instant's silence, the stars shone out bright and clear, and then came through the still air the long wail of the injured and houseless.

I have reserved till now the discussion of the origin of this tornado. I do not think it can be dismissed with the remarks that it originated as all tornados do, and as we see them constantly do on a small scale on a hot dusty highway, by the impact of two currents of air flowing in different directions, and which thus after their impact assume a rotatory motion. I do not say that this one did not so originate somewhere, but that there are good grounds for the belief that it did not so originate at Hazaribagh, where its destructive course began. I believe that it was already a whirlwind of great force before it touched ground at that place.

My reasons for this belief, which is at first sight improbable, are to my mind insuperable. They are as follows :—

All day, as usual at this season, a strong south or south-easterly breeze had been blowing. About 5 P. M., the low grumbling of an approaching " nor'-wester " became audible, and a dull slate-blue bank of clouds was seen coming up in the teeth of the wind from the north-west lit up by occasional flashes of lightning. About 6-30 P. M., the nor'wester was overhead, and a few drops of rain began to fall. In these two currents of air, a south wind blowing hard along the surface, and a high north-west current from the north-west, we have the necessary elements for the birth of a rotatory storm. About this time, Mr. Kelly, the Resident Medical Officer of the Mitford Hospital, was visiting a friend at the Railway lines to the north of the town. Mr. Kelly has spent most of his service in the North West Provinces, and is well acquainted with the appearances of dust storms, and he called the attention of his friend to a dull brown patch low over the mangoe trees to the north, contrasting with the clear slate-blue background of the approaching nor'-wester. This brown patch was travelling rapidly from west to east. He pointed out that this patch exactly resembled a distant dust storm. When it got due north of his point of observation, it seemed to become stationary or rather to be approaching Dacca. From his experience of dust storms he knew it was time to get home. When he reached the Mitford Hospital ten minutes afterwards, he looked for the brown patch, and saw it now to his north-west, *i. e.*, on its way from its former position on the north of the town to the west end of Dacca. About ten minutes afterwards he heard the sound of the tornado on its track from the west of the Lalbagh, and along the opposite bank of the river, and a large tree in the Mitford Hospital compound was blown down.

Here we have the evidence of an intelligent and trustworthy ob-

server noticing a phenomenon with which he was familiar, altogether apart from the other phenomena of the nor'-wester, following a course of its own, and approaching that part of Dacca where the tornado first struck.

Next, we have the evidence of the people living at Hazaribagh, who are consistent in their assertion that the storm came upon them, with a "lurid glare" from the north, the direction from which Mr. Kelly saw it approaching that part of the town.

Thirdly, we have the appearance presented by the ravages committed by the storm before it settled down as a tornado in the orchard to the north-east of Fakirni-ka-masjid. From these appearances alone, I was driven to the same conclusion before I had heard the evidence of the inhabitants or of Mr. Kelly. To carry the weight they deserve, these appearances must be given in some detail. The position of the first appearance of the tornado is shown in Pl. XXVII, Fig. E.

From the Elephant Depôt there is a curvilinear road leading to the old river bank at Hazaribagh, for the convenience of watering the elephants. It is known as the Hathi-ka-sarak. About half way between the Philkhana and Hazaribagh, it is crossed by the old Mirpur road. From the eastern gate of the Philkhana to the point of intersection of these two roads, not a twig or leaf was disturbed by the storm; but after passing the Mirpur road on the Hathi-ka-sarak, half way between it and the Hazaribagh ghat, one comes suddenly upon traces of a violent wind from the north. The first tree which seems to have suffered is a tall jamun tree well to the right of the road, the top branch of which has been torn off, and is hanging to the south. There is then an interval of low brushwood, and then a group of mango trees close to the road side. The top branches of all these trees are snapped across and driven to the south. On the opposite side, in a direct line with the jamun and the mango trees, all the trees for a distance of fifty paces along the road have their top branches snapped across. There is again an interval of forty paces without a leaf turned on either side of the road, but after that distance, and for another forty or fifty paces, all the top branches are seen to be knocked off the trees; on the right or north side only those quite close to the road, but on the left or Hazaribagh side there is a line of destruction towards the south ending about 200 yards away in a chaos of broken and uprooted trees. Continuing to walk along the road, there is no evidence of a storm on the right or left till we reach the old river bed, and just there is a group of tall jamun trees overhanging a mat house. One of the top branches of this group of trees has been torn off, and thrown to the south over the mat house, but not a straw of the thatch is disturbed.

Here we have evidence of a violent wind blowing from north to

south about 100 paces broad, and coming downwards at an angle of from five to ten degrees with the surface of the ground ; striking at first only the top branches of tall trees, then the upper branches, and finally snapping across the main branches or uprooting them bodily, when the violence of the wind got lower. To the north and to the east and west of this track nothing had been disturbed. I drove along the old Mirpur road far enough to satisfy myself that beyond the first jamun tree mentioned nothing had been touched.

It is to be noted that there was no evidence of rotation in this wind : everything was carried in one direction, namely, from north to south.

On the old river bed and on the bank there, were, however, evidences of a less violent gale, blowing from west to east and from the south-west to north-east, as indicated by the arrow heads ; and there were signs, to the east of this chaos, of a very violent wind blowing down trees and branches to the west and south-west. To the north-east of Fakirni-ka-masjid, was the chaos of broken and uprooted trees, centring round a group of plantain trees twisted and turned in all directions where the vortex had at once established itself.

It is open to any one to say that the vortex originated round those plantain trees, and that the arrow heads in my diagram indicate the directions of the wind as it was sucked into the vortex as it began to rotate, and that the great destruction was caused by the gradual developement of power as it continued to rotate.

I oppose this theory with the objections already stated, namely, that an unusual cloud was seen travelling towards this very place, and by the assertions of the people of the place, that the storm did not develope itself there, but burst upon them suddenly from the north, and the extreme violence of the wind at its very first manifestation, before the vortex had begun to move, is opposed to the idea of a gradual development of the whirlwind at this spot.

I hold that the other theory that the tornado was travelling in a higher stratum of air, and descended at a low angle, and struck ground at this spot is compatible with all the observations. It is what the people on the spot say did happen,—it explains the extreme violence of its very first manifestations, and the direction which it immediately took. It may be objected that the total absence of the evidence of rotation in its very first manifestation is opposed to this theory. But it is not really so. If you imagine that as the tornado struck the trees on its way to the ground the vortex was not perpendicular, but sloping towards the north-west, it will be clear that the first part to come in contact with terrestrial objects would be the right or advancing lateral radius. The other three radii would not come into action, on account of the tilting, till the vortex itself was on the ground. The next radius to come into

action would be the posterior, and we have evidence that this was so in the violence of the destruction to the east of the first track from north to south. The anterior radius being tilted most upwards would at first have the feeblest power, and it is the case that the least destruction done was in the river bank straight in front of the violent gale that broke through the trees from the north. If the vortex had gradually formed, one would have expected a more equal distribution of power around it, instead of its being chiefly at first on two sides.

The theory that the tornado already formed was travelling rapidly from north to south before it struck ground, also explains the reason for its starting at once in a south-easterly direction. The resistance of the ground was at first offered solely to one radius, the right or advancing lateral one. The result was equivalent to that of a sudden powerful push to the left, that is, to the east of the direction in which it was previously travelling. The experiment of offering resistance to a humming top at a corresponding point would illustrate the effect of the resistance of the ground to a tornado descending upon it in the way in which I suppose this one did.

The possibility of a tornado travelling in the air may appear doubtful to some, but the probability of its being able to do so, and at great speed, receives confirmation from what I consider to be the progress of this very tornado after it left Dacca. I have said that when the vortex reached the Sankari Bazar it seems to have risen rapidly into the air, for the reason that only the upper stories of the high houses of this part of the town were seriously damaged. It seems after leaving Dacca to have travelled in the air due south for a distance of 20 miles, and to have struck down again in the south of the Munshiganj subdivision of this district, destroying 5 or 6 villages, and causing 60 to 80 deaths. The time it took to travel that distance was not more than 20 minutes to half an hour. It came upon the people in the west suburbs of Dacca just as they were about to sit down to their evening meal, a few minutes after 7 P. M. It reached the neighbourhood of Rajabari in the south of Munshiganj just as they had finished their evening meal, and were preparing for their post-prandial smoke, that is, about 7.30 P. M.

It may be objected that it was not the same tornado which took these villages in Munshiganj, but another and independent one. But the improbability of two different and independent tornadoes, forming and travelling together on one evening in this part of India, where a tornado has never been known before, is, to say the least, very great.

Since writing the above, I have visited the villages referred to in the south of the Munshiganj subdivision. The people say it came from the north-west. It first struck a village called Dohori, then Barakoer, Banuri, Hashail, Silbaran, Majgaon, and Bagbari; a course altogether

of about seven miles. Its track was about east by south, and, like the Dacca one, it was about 200 paces broad. The evidences of rotation were equally clear, and the rotation was from right to left, all the trees on the right or advancing radius being blown eastwards, while those on the left or retrograding radius were broken westwards,—at Barakoer there were signs of a great indraught from the north, similar to that which occurred to the east of the Philkana at Dacca. This indraught passed over the house of Babu Kali Prasanna Ghosh, manager of the Bhowal estates. The force of the tornado was very great, and the loss of life would have been much greater, if it had not selected a comparatively open track of country for its course. In some of the villages over which it passed, it made a clean sweep of everything, leaving only the raised platforms over which the houses had stood. The people speak of men having been lifted into the air and dashed down on the ground. Twenty-one persons are said to have been killed in this way in the village of Hashail.

Dacca,
23*rd April*, 1888.

The observer at the meteorological observatory at Dacca having reported that the Tornado had passed through the compound of the Telegraph Office, and this statement having appeared in the Meteorological Report for the week ending the 13th of April, I subsequently wrote to the officiating Meteorological Reporter as foliows :—

" In your short notice which was published last week in the Gazette, you surmise that the tornado passed through the telegraph compound, but you will see from these maps that this was not so. The Telegraph Office was well to the right of its track. The trees blown down there were affected by cyclonic blasts which circled round the real tornado, and at some distance from it. You will see that there were several such blasts. One went between Beighton's house and my own, breaking down a lot of trees, and carrying away the corner of the house occupied by Messrs. Edwards and Wilson. It was such a blast that brought down the wall of the lunatic asylum, which was well away to the north of the tornado, which was at that time crossing the river. I think that the three police barracks at the Lalbagh were perhaps affected by a similar blast, only they were much nearer the vortex than the other examples now given. It is otherwise difficult to understand how only those three were affected. Some people even think that the blowing down of the asylum wall is evidence that the vortex was somewhere there. But the damage near the asylum is trivial, and there is no sign of the track either to or from that point, and I am clear that it was not near it, and that my tracing is practically correct. On the opposite side of the river it went rather more inland than I have shown."

Supplement to Dr. Crombie's Account of the Tornado of the 7th of April 1888.

STATEMENT SHOWING THE NATURE OF DAMAGE DONE BY THE TORNADO OF THE 7TH APRIL 1888 IN THE CITY OF DACCA AND KIRANIGUNJ STATION.

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STATIONS.	No. of pucca houses completely demolished.	No. of pucca houses partially demolished.	No. of cutcha barries completely demolished.	No. of cutcha barries partially demolished.	No. of boats destroyed.	Estimated value.	No. of persons killed.	No. of persons wounded seriously and treated in Hospital.	No. of persons who died in Hospital up to 16th instant.	No. of wounded persons attended in private houses by Government Doctors.	Total No. of persons wounded including those in Col. 9, 10 and 11.	REMARKS.
						Rs.						(A) I think this is a very fair estimate.
Town ...	5	93	114	61	25	588225	86	162	7	248	1200	(B) Probably 20 more than these were killed.
Lalbagh ...	4	54	2825	...	30	63359						(C) Some 5 more are likely to die.
Kiranigunj	...	1	579	...	66	26844	32	60	4			
Total ...	9	148	3518	61	121	(A) 678,428	(B) 118	222	(C) 11	248	(D) 1200	(D) These figures do not include any but fairly severe wounds.

(Sd.) J. D. CLARK,
District Superintendent of Police.